

### REMARKS

The specification has been amended to correct errors of a typographical and grammatical nature. Due to the number of corrections thereto, applicants submit herewith a Substitute Specification, along with a marked-up copy of the original specification for the Examiner's convenience. The substitute specification includes the changes as shown in the marked-up copy and includes no new matter. Therefore, entry of the Substitute Specification is respectfully requested.

The claims have also been amended to more clearly describe the features of the present invention, and the abstract has been replaced by a new abstract, thereby correcting errors of a grammatical nature and providing an abstract in proper format.

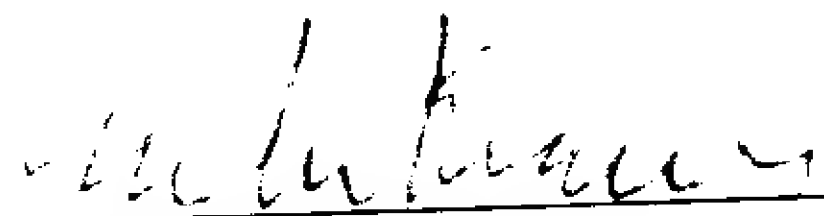
Also submitted herewith is a proposed amendment to the drawings, wherein Fig. 1 has been amended at this time. Upon receipt of the approval of the amendment to the drawings and receipt of a Notice of Allowance, the proposed drawing corrections will be effected in accordance with present practice.

Entry of the preliminary amendments and examination of the application is respectfully requested.

To the extent necessary, applicant's petition for an extension of time under 37 CFR 1.136. Please charge any shortage in the fees due in connection with the filing of this

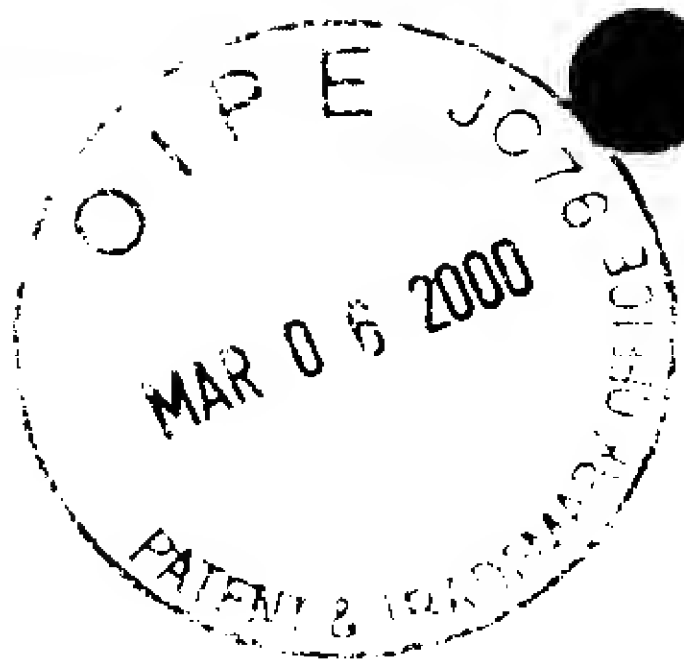
paper, including extension of time fees, to Deposit Account  
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Respectfully submitted,



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TITLE OF THE INVENTION  
DISPLAY APPARATUS

BACKGROUND OF THE INVENTION

5 In order to obtain <sup>a display apparatus which is capable of producing a</sup> [the] high definition display apparatus, various surface treatment films have been formed on <sup>the</sup> surface of the display plane. For instance, <sup>the use of</sup> an anti-static anti-reflection film <sup>has been proposed,</sup> [was formed] as disclosed in JP-A-4-334853 (1992). Furthermore, <sup>the use of</sup> a wavelength selective absorption film, which <sup>is capable of absorbing</sup> [absorbed] side bands of emission spectrum selectively, by adding coloring material for improving <sup>the</sup> color purity of an emitter, <sup>has been proposed,</sup> [was formed] as disclosed in JP-A-4-144733 (1992), because the emission spectrum of <sup>the</sup> RGB emission of <sup>a</sup> [the] Braun tube <sup>is</sup> [was] wide and <sup>the</sup> bleeding of <sup>color tends to occur</sup> [Color was generated].

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One of the anti-static, anti-reflection films is formed by laminating oxide thin films having a different refractive index <sup>on</sup> each other, in order to <sup>give the film</sup> [make it have] an anti-reflection effect by optical interference, and <sup>this film</sup> [it] is mainly formed by laminating a SiO<sub>2</sub> film <sup>as an</sup> [at] upper layer <sup>on</sup> (and) an ITO (InO added with Sn) film <sup>as an</sup> [at] lower layer. Because ITO is a conductive film, the anti-reflection film itself has <sup>is an</sup> an anti-static effect. Not only <sup>needed</sup> [the] anti-static effect, but also an electromagnetic shielding function is required for the surface treatment film of <sup>a</sup> [the] Braun tube.

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One of the wavelength selective absorption films is formed by adding a reddish violet group coloring material into a thin film, in order to absorb side bands of emission

spectrum of green and red, and a Braun tube having a high contrast, <sup>with such a film</sup> is provided, (Toshiba Review, vol. 45, No. 10, p831 (1990)).

## 5 SUMMARY OF THE INVENTION

The present invention relates to a display apparatus, particularly to a surface treating film <sup>for a</sup> [of the] display apparatus, such as <sup>a</sup> Braun tube, plasma display, and the like, for <sup>providing a</sup> [making the] high definition display apparatus.

10 However, the prior <sup>efforts</sup> [art] described above <sup>a</sup> [are] <sup>have proven to be</sup> insufficient for development of high definition Braun tube. Conventionally, a high definition Braun tube, <sup>using</sup> [whereon] a surface treatment film having a low reflection, a low resistance, and a wavelength selective absorption effect, 15 has not been developed, yet. For improving <sup>the</sup> [high] contrast of <sup>a</sup> [the] Braun tube, an anti-reflection <sup>characteristics</sup> [characteristics] is required, wherein the reflectance is controlled by laminating films having a wavelength selectivity by adding coloring material <sup>so that the films will have relative to</sup> [and] different refractive indexes, each 20 other. It is well known that, when <sup>a</sup> [the] coloring material is added, <sup>to a material</sup> the refractive index <sup>of this material</sup> is varied in the absorption wavelength region of the coloring material. When <sup>an</sup> [the] anti-reflection is realized by optical interference effect, the optical interference effect is undesirably 25 influenced, because the refractive index is varied by an abnormal dispersion of the refractive index of the coloring material. Therefore, the refractive index curve does not become flat, but <sup>exhibits a</sup> [generates] waviness and an abnormal region

to increase the refractive index and so on, and, the  
 performance as <sup>an</sup> [the] anti-reflection film is deteriorated.

In consideration of <sup>a</sup> variation in reflectance when  
 the coloring material is added, when coloring materials  
 5 of red, blue, and green are added, the refractive index  
 is changed in respective <sup>ones</sup> of the absorption regions, such  
 as <sup>by its</sup> increasing <sup>first</sup> [once] in accordance with <sup>a</sup> decreasing <sup>d</sup> the  
 wavelength, and subsequently decreasing. Therefore, a  
 relationship between the refractive indexes of the upper  
 10 layer and that of the lower layer are inverted <sup>relative to</sup> each other,  
 and <sup>so</sup> the control of the refractive indexes <sup>becomes</sup> [become] difficult.  
 When <sup>a</sup> [the] coloring material is added to the laminated films,  
 the refractive index curve is varied depending on whether  
 the coloring material is added to the upper layer [1] or the  
 15 lower layer. Accordingly, the reflectance can be  
 decreased in a specified region by using <sup>a</sup> change of  
 refractive index of the coloring material, but in the  
 region wherein the refractive index is inverted, the  
 refractive index is increased because the refractive  
 20 indexes of the films of the upper layer and the lower layer  
 are inverted <sup>relative to</sup> each other.

However, as a result, the refractive index of the  
 film is decreased <sup>so as to be</sup> smaller than the high refractive index  
 of the original oxide film <sup>due to the addition of</sup> [by adding] the coloring material,  
 25 because the refractive index of the oxide and the  
 refractive index of the coloring material are averaged.  
 Accordingly, <sup>with regard to</sup> [as] the reflectance curve, the value at the  
 bottom is increased, because the difference <sup>between</sup> [of] the



refractive indexes of the upper and lower layers is decreased.

Furthermore, a low resistance film is necessary for <sup>a</sup>the Braun tube, because <sup>the</sup> functions of anti-static and electromagnetic shielding are required for <sup>a</sup>the Braun tube. ITO is used most widely at present. However, if <sup>a</sup>the coloring material is added, the resistance of the ITO is increased. The resistance tends to increase <sup>in opposition</sup> [inversely] to the requirement for <sup>a</sup>low resistance, because the concentration of the coloring material tends to increase in order to enhance the wavelength selective absorption effect.

The object of the present invention is to provide a display apparatus <sup>using</sup> [formed] a surface treatment film having a low reflection, low resistance, and <sup>a</sup>wavelength selective absorption effect.

In order to achieve the <sup>purpose</sup> [above] object, the present invention <sup>provides a</sup> [is characterized in that the] display apparatus [of the present invention is provided] with a surface treatment film having a luminous transmittance equal to or less than 85 %, a luminous reflectance equal to or less than 2 %, and a flattened reflectance curve, <sup>in</sup> [of] which absolute values of differential values are equal to or less than 2. Furthermore, the present invention is characterized in that the surface treatment film has <sup>a</sup> selective absorption at approximately 450 nm, 570 nm, and 650 nm, and a sheet resistance equal to or less than 10000  $\Omega/\square$ .

<sup>A</sup>  
 (The) high definition display apparatus having a  
 wavelength selective absorption anti-reflective anti-  
 static film <sup>according to</sup> [of] the present invention, comprises a film  
 laminated with at least three <sup>film</sup> layers <sup>including a</sup> [of] protective film, <sup>a</sup>  
 5 conductive film, and <sup>an</sup> absorption film, <sup>the</sup> on surface of the  
 display plane, and the laminated film is composed <sup>such</sup> [of] that  
 the conductive film is arranged at a position closer to  
 the surface of the display plane than the absorption film  
<sup>which contains</sup> [containing] coloring material. The laminated film has a  
 10 luminous transmittance equal to or less than 85 %, a  
 luminous reflectance equal to or less than 2 %, a flattened  
 reflectance curve, and a resistance equal to or less than  
 10000  $\Omega/\square$ . The conductive film is composed of at least  
 one <sup>metal</sup> [of metals] selected from the group consisting of Ag,  
 15 Pd, Pt, Cu, Cr, and Au. Furthermore, any one of ATO (SnO<sub>2</sub>  
 added with antimony) and ITO, which are conductive <sup>oxides</sup> [oxide],  
 can be used. The absorption film containing coloring  
 material is composed of at least one of dyes and pigments,  
 selected from the group consisting of dyes and pigments  
 20 having an absorption at 450 nm, dyes and pigments having  
 an absorption at 570 nm, and dyes and pigments having an  
 absorption at 650 nm.

<sup>A</sup>  
 (The) high definition display apparatus having a  
 wavelength selective absorption anti-reflective, anti-  
 static film <sup>according to</sup> [of] the present invention, comprises a film  
 25 laminated with <sup>film layers including a</sup> protective film, <sup>a</sup> conductive film, and <sup>an</sup>  
 absorption film, <sup>a</sup> on surface of the display plane; the  
 laminated film is <sup>formed such</sup> [composed so] that a first layer from the

surface of the display plane is the protective film made of mainly  $\text{SiO}_2$ , a second layer is the conductive film composed of at least one <sup>with</sup> [of metals] selected from the group consisting of Ag, Pd, Pt, Cu, and Cr, and a third [film] <sup>layer</sup> is the absorption film containing coloring material; and, the laminated film has a luminous transmittance equal to or less than 85 %, a luminous reflectance equal to or less than 2 %, a flattened reflectance curve, and a resistance equal to or less than  $10000 \Omega/\square$ . Furthermore, the laminated film has an absorption equal to or less than 75 % at approximately 450 nm, an absorption equal to or less than 65 % at approximately 570 nm, and an absorption <sup>and, it has</sup> equal to or less than 75 % at approximately 650 nm; a luminous reflectance equal to or less than 1 %, a flattened reflectance curve, and a resistance equal to or less than  $10000 \Omega/\square$ .

In accordance with the present invention, a wavelength selective absorption anti-reflective, anti-static film is utilized for <sup>a</sup> display apparatus, such as <sup>display panel</sup> Braun <sup>tube</sup> [tubes], plasma <sup>display panel</sup> [displays] and so on.

The protective film is made of mainly  $\text{SiO}_2$  <sup>which</sup> and <sup>serves to maintain</sup> [aimed] [at maintaining] the strength of laminated surface treatment film. The conductive film is made of metal or a conductive oxide for anti-static and electromagnetic shielding. Reflection is prevented by <sup>which form</sup> two layers [of] the protective film and the conductive film. The absorption film contains coloring material, and its function is to absorb/wavelength selectively.



When coloring material is added, the refractive index of the film is varied depending on the absorption of <sup>the</sup> wavelength by the coloring material. Therefore, if <sup>the</sup> reflection is prevented by an interference effect of light, the interference effect of light is influenced by <sup>a</sup> variation of the refractive index. It is difficult to flatten the reflectance curve by decreasing the variation of the refractive index. In particular, if a large amount of the coloring material is added in order to increase the wavelength selective absorption effect, the variation of the refractive index in the absorption region <sup>(is)</sup> <sup>becomes</sup> remarkable. <sup>P</sup> The reflectance of the anti-reflection film is expressed as a luminous reflectance, which is an area of the curve obtained by multiplying the reflectance of the film in a visible light region of 380 nm-780 nm with the luminous sensitivities of the respective wavelengths. The luminous sensitivity is 1.0 at 555 nm. The luminous sensitivity is decreased as the wavelength <sup>becomes more distant</sup> <sup>(takes distance)</sup> from 555 nm, which is regarded as a standard, <sup>on</sup> <sup>(in)</sup> both sides, and the luminous sensitivity becomes zero at 380 nm and 780 nm. <sup>P</sup> Because the luminous reflectance is a product of the luminous sensitivity and <sup>the</sup> reflectance curve, <sup>the value</sup> <sup>at</sup> 555 nm is small, <sup>or</sup> it becomes small only if the reflectance curve is flat, and not a U-shaped curve, but approximately a straight line. If <sup>a</sup> change of the refractive index is increased by addition of <sup>a</sup> coloring material, the reflectance curve does not become flat, and the luminous reflectance can not be decreased. In

particular, when a red group coloring material is added, its absorption wavelength is in the range of 540-590 nm having a high luminous sensitivity, and influence of the change in the refractive index <sup>on</sup> to the luminous reflectance is remarkable. <sup>P</sup>As explained above, it is difficult to decrease the luminous reflectance by forming the wavelength selective absorption anti-reflection film by adding <sup>a</sup> coloring material <sup>thence</sup>.

Therefore, in order to form an anti-reflection film having wavelength selective absorption characteristics by adding coloring material, the composition of the present invention is necessary. <sup>P</sup>The anti-reflection characteristics can be obtained by utilizing <sup>the</sup> interference effect of light generated by laminating films having different refractive indexes <sup>on</sup> each other. As the number of laminated layers is increased, the intensity of <sup>the</sup> light is decreased as <sup>the position of</sup> the film comes close to <sup>the</sup> bottom. Therefore, the reflectance curve can be flattened by arranging the film <sup>to which</sup> added with coloring material <sup>is added</sup> at <sup>the lowest</sup> a lower position in the layers as possible, because <sup>the</sup> contribution of the film <sup>is</sup> added with coloring material to the anti-reflection can be decreased. <sup>P</sup>Furthermore, reflection of extraneous light can be increased by using a film having a high reflectance, such as <sup>a</sup> metallic film. Accordingly, if a metallic film is arranged at a position <sup>higher</sup> upper than the film <sup>is added</sup> added with coloring material, the intensity of extraneous light <sup>which reaches</sup> reached the film <sup>added</sup> added with the coloring material is decreased. As <sup>a</sup> the result, the contribution

of the film to the anti-reflection effect can be decreased, and both the effects of wavelength selective absorption [characteristics] and [the] anti-reflection can be obtained with, small number of laminated layers.

5 Here, the number of laminated layers means at least three laminated layers. In view of manufacturing<sup>requirements</sup>, the number of laminated layers<sup>desirably should be</sup> as small as possible [is] [desirable]. Manufacturing the wavelength selective absorption anti-reflection film with [a] small<sup>as a</sup> number of  
 10 laminated layers as possible can be achieved by using a film having an extremely large refractive index. <sup>P</sup> The film [added with]<sup>to which</sup> coloring material<sup>is added produces</sup> [generates] a change in refractive index in the absorption wavelength region and a  
 15 decrease in the anti-reflection effect. However, when the film [added]<sup>added</sup> with coloring material is arranged at a position lower than a high reflection layer, the intensity of<sup>the</sup> reflected light at the boundary of the film [added]<sup>added</sup> with coloring material is decreased remarkably, and the contribution to the interference of light can be  
 20 decreased. <sup>thus</sup> [Then], in accordance with the present invention, a metallic film such as Ag, Pd, Pt, Cr, Cu, and Au was used as the high reflection film. The metallic film has a small resistance[,] and operates as an electromagnetic shielding film. The reflectance is  
 25 large, the intensity of extraneous light<sup>which reaches a</sup> [reached the] film lower than the metallic film is small, and it is scarcely necessary to worry about<sup>this</sup> light resistance of the coloring material for the wavelength selective absorption film.

Generally, coloring material is decomposed by ultraviolet  
 ray, and the light resistance is weak. Conventionally,  
 pigment group coloring materials having a strong light  
 resistance as a coloring material, but undesirable  
 5 absorption characteristics, have been used as the  
 coloring material. However, in accordance with the  
 composition of the present invention, dye group coloring  
 materials having [a] desirable absorption characteristics,  
 but weak light resistance, can be used, <sup>with the result that</sup> [and] a high  
 10 performance display apparatus having [a] preferable  
 wavelength selective absorption characteristics can be  
 manufactured.

#### BRIEF DESCRIPTION OF THE DRAWINGS

15 FIG. 1 is a partial cutaway side view of <sup>a</sup> [the] Braun  
 tube relating to <sup>an</sup> [the] embodiment of the present invention [ ];  
 FIG. 1(a) is a sectional view of the area A in FIG. 1;

FIG. 2 is <sup>a graph of</sup> [an] observed results of reflectance and  
 transmittance <sup>in a</sup> [of the] Braun tube relating to the embodiment  
 of the present invention [ ];

20 FIG. 3 is a partial cutaway <sup>perspective</sup> [side] view of the plasma  
 display relating to the embodiment of the present  
 invention [ ];

FIG. 4 is a [schematic] cross section indicating the  
 composition of the surface treatment film relating to the  
 25 embodiment of the present invention [ ];

FIG. 5 is a [schematic] cross section indicating the  
 composition of the surface treatment film relating to the  
 embodiment of the present invention [ ];



FIG. 6 is a [schematic] cross section indicating the composition of the surface treatment film relating to the comparative example of the present invention[<sup>1</sup>]; and

FIG. 7 is a [schematic] cross section indicating the composition of the surface treatment film relating to the comparative example of the present invention.

#### PREFERRED EMBODIMENTS OF THE PRESENT INVENTION

(Embodiment 1)

As an embodiment of the present invention, an example of [manufacturing] a Braun tube <sup>representing</sup> [composing] the display apparatus <sup>of the invention will be</sup> [is] explained, hereinafter.

FIG. 1 is a partially cutaway side view <sup>illustrating</sup> [indicating] a Braun tube 1 <sup>representing an</sup> [of the] embodiment of the present invention.

FIG. 2 is a graph indicating an observed result relating to the relationship between each of a reflectance (indicated by the curve 13 in the figure) and a transmittance (indicated by the curve 14 in the figure) of the surface treatment film of the Braun tube with <sup>respect to the</sup> wavelength of light in the present embodiment. P The high

definition Braun tube 1 comprises a housing 2 made of glass, of which <sup>the</sup> interior is evacuated. The housing 2 comprises a neck 3, a funnel portion 4 <sup>which continues</sup> [continued] from the neck 3, and a face plate 5 sealed by frit glass. <sup>The outer</sup> [Outer] peripheral side wall of the face plate 5 <sup>has</sup> [is wound with] a metallic tension band 6 <sup>wound thereon</sup> for anti-explosion. An electron gun 7 for discharging <sup>an</sup> electron beam is arranged <sup>in</sup> (at) the neck 3. A plurality of fluorescent members (generally fluorescent



layers of three colors such as red, green, and blue<sup>phosphor</sup> applied in a dotted pattern or a stripe pattern<sup>]</sup> and a fluorescent screen 8, which is composed of black absorbing layers in a dotted pattern or a stripe pattern arranged between each of the fluorescent layers, are provided at<sup>on</sup> inner surface of the face plate 5.

A CRT display apparatus (a cathode ray tube display apparatus) is <sup>formed</sup> composed by connecting the Braun tube 1 to display control circuits, such as (a) horizontal and vertical deflection<sup>circuits</sup> circuit, power source circuits, and the like. That is, in accordance with the<sup>typical</sup> cathode ray tube display apparatus, <sup>the</sup> scanning<sup>of electron beams</sup> by electrons, which are accelerated by the cathode voltage of the electron gun 7 of the cathode ray tube, is performed by <sup>supplying a</sup> flowing sawtooth current <sup>at</sup> [of] horizontal cycles and sawtooth current<sup>at</sup> [of] vertical cycles, respectively, to coils arranged in the vicinity of <sup>the</sup> path of the electron<sup>beams</sup> beam from each of horizontal and vertical deflection circuits, and image displaying is performed by <sup>scanning the electron beam in</sup> forming a raster. The scanning lines<sup>traced</sup> by the accelerated <sup>electron beams</sup> [electrons] are projected <sup>on</sup> [to] a luminescent screen 8 via <sup>a</sup> shadow<sup>mask</sup> (masks) which<sup>is</sup> [are] not <sup>illustrated</sup> [indicated] in the figure.

One of the feature of the present embodiment is that a wavelength selective absorption anti-reflective, anti-static film 12 is provided <sup>on an</sup> [at] outer surface of the face plate 5 of the Braun tube 1. <sup>the details of which are illustrated in</sup> FIG. 1(a)

A method <sup>of</sup> [for] preparing the wavelength selective absorption anti-reflective, anti-static film 12 <sup>is</sup> <sup>will be</sup> explained<sup>by way of example</sup> hereinafter. A coating solution, which was

prepared by adding a rhodamine group coloring material, as  
 a reddish violet group coloring material, Cu  
 phthalocyanine, as a blue group coloring material, and a  
 yellow group coloring material to silica sol, was coated  
 5 onto the surface of the Braun tube by [a) spin coating [by] at  
 160 rpm, and, dried at 60 °C for 5 minutes to form a SiO<sub>2</sub>  
 film<sup>9</sup> containing<sup>a</sup> coloring material [9] on the face plate 5.

The composition of <sup>this</sup> [the] solution <sup>was</sup> [is] as follows:

SiO<sub>2</sub>: 2 wt.%, sulforhodamine B: 0.05 wt.%, Cu  
 10 phthalocyanine: 0.06 wt.%, ethanol: 20 wt. %, sodium  
 fluoresein: 0.02 wt.%, water: 10 wt.%, and propanol:  
 residual.

Then, a fine particle Ag-Pd dispersion liquid was  
 applied by a spin coating method [with] <sup>at</sup> 160 rpm <sup>and</sup> dried at  
 15 60 °C for 5 minutes, to laminate an Ag-Pd film 10 onto the  
 SiO<sub>2</sub> film<sup>9</sup> containing<sup>a</sup> coloring material [9]. Finally, silica  
 sol was applied by a spin coating method [with] <sup>at</sup> 160 rpm <sup>and</sup> dried  
 at 60 °C for 5 minutes, to form a SiO<sub>2</sub> film 11.

Subsequently, <sup>the formation of</sup> the wavelength selective absorption  
 20 anti-reflective, anti-static film 12 was <sup>completed</sup> [prepared] on the  
 face plate 5 by heating the laminated films to 160 °C with  
 a velocity of 20 °C/min., heat-treating <sup>them</sup> at 160 °C for 15  
 minutes, and cooling <sup>them</sup> to room temperature with a velocity  
 of 20 °C/min.

25 As <sup>a</sup> [the] result, the surface resistance of the  
 manufactured wavelength selective absorption anti-  
 reflective, anti-static film 12 was 350 Ω/□, and [each]  
 [of] the transmittance and the reflectance <sup>were</sup> [was] as indicated

by <sup>respectively</sup> of the curve 13 and the curve 14, in FIG. 2.

A selective absorption film having <sup>o</sup>transmittance of 75 % at 450 nm, 59 % at 570 nm, and 85 % at 650 nm, was obtained.

<sup>The luminous</sup> Luminous transmittance of the film was approximately 85 %.

- 5 A Braun tube having a reflectance of 5.8 % at maximum in the visible light region, 0.36 % at minimum with 555 nm, and a flat reflecting <sup>characteristics was</sup> [characteristics could be] manufactured. The luminous reflectance of the film was 0.85 %. Absolute values of <sup>the</sup> calculated differentials of
- 10 the reflectance curve were equal to or less than 2. As explained above, the reflectance could be flattened, even if the wavelength selective absorption effect was added by adding coloring material.

<sup>and the</sup> Here, surface treatment films having various <sup>concentrations</sup> [concentration] of the coloring material in the film were prepared, and their contrast <sup>was</sup> [were] calculated based on their RGB emission spectrum intensity and transmittance. It was revealed that the <sup>desired</sup> effect could be obtained if the luminous transmittance was in the range of 40-85 %. <sup>Thus</sup> [Then], it was

20 decided that the luminous transmittance should be in the range of 40-85 %. However, if the luminous transmittance is in the range of 40-50 %, the brightness is decreased. Therefore, <sup>a</sup> [the] range of 50-85 % is <sup>more</sup> desirable.

Then, films having <sup>the</sup> different transmittance <sup>with respect to</sup> each other were prepared by varying <sup>the</sup> concentration of the coloring material <sup>added</sup> to the absorption film, and their <sup>contrasts</sup> [contrast] were calculated <sup>in</sup> [by] the same manner <sup>as before</sup>. It was revealed that the contrast was improved when <sup>each of</sup> the

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transmittance at 450 nm, 570 nm, and 650 nm was in the range of 85-40 %, 65-35%, and 90-45 %, respectively. However, when the values at 450 nm and 650 nm were at least 75 %, and the value at 570 nm was at least 40 %, <sup>the</sup> blackness of the film was diminished, and it became difficult to maintain <sup>the</sup> color balance. The transmittance of the coloring material at each of 450 nm, 570 nm, and 650 nm <sup>should be</sup> [is] desirably in the range of 85-40 %, 65-35%, and 90-45 %, respectively, but preferably <sup>it is</sup> in the range of 75-40 %, 65-40%, and 75-45 % at 450 nm, 570 nm, and 650 nm, respectively.

10 [The films] <sup>with respect to</sup> having different thickness, each other [of] to form the protective film, conductive film, and absorption film were prepared. It was revealed that, if <sup>a</sup> [the] protective film, i.e., <sup>the</sup> SiO<sub>2</sub> film, having a thickness [of] equal to or 15 less than 150 nm, <sup>a</sup> [the] conductive film having a thickness [of] equal to or less than 50 nm, and <sup>an</sup> [the] absorption film having a thickness [of] equal to or less than 1200 nm were combined, the luminous reflectance became equal to or less than 1 %. However, the strength of the protective film 20 is decreased when the film thickness is equal to or less than 40 nm, the resistance of the conductive film is increased when the film thickness is equal to or less than 20 nm, and <sup>a</sup> decrease of the film strength and bleeding of the coloring material of the absorption film is generated, 25 because the concentration of the coloring material is increased in order to obtain the designated transmittance when the film thickness is equal to or less than 300 nm. Accordingly, the protective film is desirably in the range



of 150-40 nm, the conductive film is desirably in the range of 20-50 nm, and the absorption film is desirably in the range of 300-1200 nm.

An alloy of Ag-Pd was used for forming the conductive film. <sup>Conductive</sup> [The conductive] films having various <sup>ratio</sup> [ratio] of Ag-Pd, <sup>respectively</sup> [respectively], were prepared. The surface resistance of the film was scarcely changed depending on the ratio of Ag-Pd, but <sup>a</sup> difference in chemical resistance was generated [each other] depending on the ratio of Ag-Pd. It was revealed that, if the ratio of Ag-Pd was in the range of 6:4 - 9:1, the film was resistive against any of <sup>various</sup> acids and bases, such as HCl and NH<sub>4</sub>OH. In some cases, an anti-chemical property of <sup>a</sup> Braun tube surface becomes a problem depending on <sup>the</sup> [using] <sup>in which it is used</sup> environment, or <sup>the</sup> <sup>employed</sup> cleaning operation. Generally, the cleaning operation is performed using water and a neutral cleaner, and the [using] environment is in offices or the like. However, in some cases, acidic or alkaline cleaners are used in the cleaning operation, or the Braun tube is used in a laboratory where various chemicals are used. The surface treatment film of the present embodiment could be a film which <sup>is</sup> [was] not restricted to any [using] environment, nor deteriorated by any cleaners.

The kind of the coloring material <sup>which is used</sup> is not restricted to the above-described materials, but any of <sup>various</sup> dyes and pigments, which have an absorption at the wavelength corresponding to any one of reddish violet, blue, and yellow, can be used. Similar results could be obtained by using any conductive film made of Ag, Pd, Cu, Pt, Cr,



or Au, in addition to Ag-Pd.

Furthermore, the surface treatment film, such as,  
described above <sup>can be</sup> [was] applied to other <sup>types of</sup> display apparatus,  
for instance, a plasma display device.

5 The high definition plasma display <sup>device</sup> manufactured in,  
the present <sup>embodiment</sup> is composed of a structure <sup>such as illustrated</sup> [indicated]  
in FIG. 3. [Electrodes for negative electrode] <sup>negative electrodes</sup> 16 are formed  
on a back plane plate 15, and [furthermore,] display cells  
20 composed of barriers 17, auxiliary cells 18, and priming  
10 spaces 19 are formed thereon. The display cells are coated  
with fluorescent materials 21, 22, 23 corresponding to  
respective [of] <sup>colors</sup> RGB. [Electrodes for positive electrode] <sup>positive electrodes</sup> 24  
and auxiliary electrodes 25 are formed on an upper layer [,  
and] <sup>are</sup> sealed with a front plane plate 26. [The] <sup>A</sup> surface  
15 treatment film 27 <sup>is</sup> [was] formed on the front plane plate 26.  
The composition of the surface treatment film was <sup>the</sup> (as) same  
as that of the Braun tube <sup>illustrated</sup> [indicated] in FIG. 1.

The manufactured high definition plasma display <sup>device</sup> was  
superior in selective absorption characteristics and  
20 reflection preventing characteristics, and <sup>had an</sup> improved [in]  
visibility.

As described above, it was revealed that the surface  
treatment film of the present <sup>embodiment</sup> [embodiment] could be applied  
to display apparatus other than Braun tube.

25

(Embodiment 2) <sup>was manufactured</sup>

Next, a film, wherein an organic resin was added to  
the SiO<sub>2</sub> film containing coloring material at the lowest

layer, as <sup>illustrated</sup> indicated in FIG. 4, was manufactured. The method <sup>will be</sup> <sup>in way of example</sup> for manufacturing the film <sup>is</sup> explained hereinafter.

The  $\text{SiO}_2$  film <sup>28</sup> containing resin and coloring material (28) was formed on a face plate 5 by spin-coating a coating solution, prepared by adding acrylic resin and the coloring material into silica sol, onto <sup>a</sup> surface of a Braun tube [by] <sup>at</sup> 160 rpm, <sup>followed by</sup> and drying at  $60^\circ\text{C}$  for 5 minutes. Then, a Ag-Pd film 29 was laminated onto the  $\text{SiO}_2$  film <sup>28</sup> containing resin and coloring material [28] by applying a Ag-Pd fine particles dispersion solution onto the  $\text{SiO}_2$  film <sup>and</sup> spin coating [by] <sup>at</sup> 160 rpm, <sup>followed by</sup> and drying at  $60^\circ\text{C}$  for 5 minutes. Finally, a  $\text{SiO}_2$  film 30 was formed on the Ag-Pd film 29 by spin coating a  $\text{SiO}_2$  film onto the Ag-Pd film 29 <sup>at</sup> [by] 160 rpm, and drying <sup>the film</sup> at  $60^\circ\text{C}$  for 5 minutes.

15 The composition of the solution prepared by adding resin and coloring material was as follows:

$\text{SiO}_2$ : 2 wt.%, rhodamine B: 0.05 wt.%, ethanol: 20 wt.%, Cu phthalocyanine: 0.06 wt.%, water: 10 wt.%, sodium fluorescein: 0.02 wt.%, acrylic resin: 1 wt.%, and  
20 propanol: residual.

Then, <sup>the formation of</sup> a wavelength selective absorption anti-reflective, anti-static film 31 was <sup>completed</sup> [prepared] on the face plate 5 by heating the laminated film to  $160^\circ\text{C}$  with a velocity of  $20^\circ\text{C}/\text{min.}$ , heat-treating <sup>the film</sup> at  $160^\circ\text{C}$  for 15  
25 minutes, and cooling <sup>the film</sup> to room temperature with a velocity of  $20^\circ\text{C}/\text{min.}$

(Embodiment 3)

Next, a film, wherein ATO fine particles <sup>was</sup> added to the  $\text{SiO}_2$  film containing coloring material at the lowest layer, as <sup>indicated</sup> in FIG. 5, <sup>was</sup> manufactured. The method <sup>by way of example</sup> for manufacturing the film <sup>is</sup> explained <sup>hereinafter</sup>.

5 The  $\text{SiO}_2$  film <sup>32</sup> containing ATO and coloring material <sup>32</sup> was formed on a face plate 5 by spin-coating a coating solution, prepared by adding ATO fine particles and the coloring material into silica sol, onto <sup>a</sup> surface of a Braun tube <sup>at</sup> 160 rpm, and <sup>then the solution</sup> drying at  $60^\circ\text{C}$  for 5 minutes. Then, <sup>32</sup> a Ag-Pd film 33 was laminated onto the  $\text{SiO}_2$  film containing ATO and coloring material <sup>32</sup> by applying a Ag-Pd fine particles dispersion solution onto the  $\text{SiO}_2$  film, performing spin coating <sup>at</sup> 160 rpm, and drying <sup>the film</sup> at  $60^\circ\text{C}$  for 5 minutes. Finally, a  $\text{SiO}_2$  film 34 was formed on the <sup>at</sup> Ag-Pd film 33 by spin coating a  $\text{SiO}_2$  film onto the Ag-Pd film 33 <sup>the film</sup> at 160 rpm, and drying at  $60^\circ\text{C}$  for 5 minutes.

The composition of the solution prepared by adding resin and coloring material was as follows:

20  $\text{SiO}_2$ : 2 wt.%, rhodamine B: 0.05 wt.%, ethanol: 20 wt.%, Cu phthalocyanine: 0.06 wt.%, water: 10 wt.%, sodium fluorescein: 0.02 wt.%, ATO fine particles: 2 wt.%, and propanol: residual. The ATO used was a commercially available one, and ASR-4 made by Sumitomo Osaka Cement co. was used.

25 Then, <sup>the formation of</sup> a wavelength selective absorption anti-reflective, anti-static film 35 was <sup>completed</sup> prepared on the face plate 5 by heating the laminated film to  $160^\circ\text{C}$  with a velocity of  $20^\circ\text{C}/\text{min.}$ , heat-treating <sup>at</sup> at  $160^\circ\text{C}$  for 15

minutes, and cooling <sup>it</sup> to room temperature with a velocity of 20 °C/min.

(Comparative example 1)

5 For comparison, a film, <sup>was manufactured</sup> wherein a coloring material was added to the SiO<sub>2</sub> film at the uppermost layer, as <sup>illustrated</sup> [indicated] in FIG. 6, <sup>will be</sup> was manufactured. The method <sup>by way of example</sup> [for] manufacturing the film, <sup>is</sup> [is] explained, [hereinafter].

The SiO<sub>2</sub> film 36 was formed on a face plate 5 by  
10 spin-coating a silica sol coating solution onto <sup>a</sup> surface of a Braun tube <sup>at</sup> [by] 160 rpm, and <sup>then</sup> drying <sup>it</sup> at 60 °C for 5 minutes. Then, a Ag-Pd film 37 was laminated onto the SiO<sub>2</sub> film 36 by applying a Ag-Pd fine particles dispersion solution onto the SiO<sub>2</sub> film, spin coating <sup>at</sup> [by] 160 rpm, and drying <sup>it</sup> at 60 °C  
15 for 5 minutes. Finally, a SiO<sub>2</sub> film 38 was formed on the Ag-Pd film 37 by spin coating a SiO<sub>2</sub> solution <sup>to which a</sup> [added with] coloring material, <sup>was added</sup> onto the Ag-Pd film 37 <sup>at</sup> [by] 160 rpm, and <sup>then</sup> drying <sup>it</sup> at 60 °C for 5 minutes.

The composition of the SiO<sub>2</sub> solution <sup>added</sup> [added] with coloring material was as follows:

SiO<sub>2</sub>: 2 wt.%, rhodamine B: 0.05 wt.%, ethanol: 20 wt.%, Cu phthalocyanine: 0.06 wt.%, water: 10 wt.%, sodium fluorescein: 0.02 wt.%, and propanol: residual.

Then, <sup>the formation of</sup> a wavelength selective absorption, anti-  
25 reflective anti-static film 39 was <sup>completed</sup> [prepared] on the face plate 5 by heating the laminated film to 160 °C with a velocity of 20 °C/min., heat-treating <sup>it</sup> at 160 °C for 15 minutes, and cooling <sup>it</sup> to room temperature with a velocity



of 20 °C/min.

(Comparative example 2)

Furthermore, for comparison, a film, wherein <sup>was manufactured</sup> [the] coloring material was added into the Ag-Pd film, as <sup>illustrated</sup> [indicated] in FIG. 7 <sup>will be</sup> was manufactured. The method <sup>by way of example</sup> [for] manufacturing the film <sup>is</sup> explained <sup>hereinafter</sup>.

A SiO<sub>2</sub> film 40 was formed on a face plate 5 by spin-coating a silica sol coating solution onto surface of a Braun tube <sup>at</sup> <sup>then the film</sup> [by] 160 rpm, and drying at 60 °C for 5 minutes. Then, a Ag-Pd film 41 was laminated onto the SiO<sub>2</sub> film 40 by applying a Ag-Pd fine particles dispersion solution [added] with <sup>a</sup> [the] coloring material onto the SiO<sub>2</sub> film, spin coating <sup>at</sup> <sup>then the film</sup> [by] 160 rpm, and drying at 60 °C for 5 minutes. Finally, a SiO<sub>2</sub> film 42 was formed on the Ag-Pd film 41 [added with coloring material] by spin coating a SiO<sub>2</sub> film onto the Ag-Pd film [added with coloring material] 41 <sup>at</sup> <sup>then the film</sup> [by] 160 rpm, and drying at 60 °C for 5 minutes.

The composition of the solution prepared by adding resin and coloring material was as follows:

Ag-Pd fine particles : 1 wt.%, rhodamine B: 0.05 wt.%, ethanol: 20 wt.%, Cu phthalocyanine: 0.06 wt.%, water: 10 wt.%, sodium fluorescein: 0.02 wt.%, and propanol: residual.

Then, <sup>this formation of</sup> a wavelength selective absorption anti-reflective anti-static film 43 was <sup>completed</sup> [prepared] on the face plate 5 by heating the laminated film to 160 °C with a velocity of 20 °C/min., heat-treating <sup>at</sup> at 160 °C for 15



minutes, and cooling<sup>ing</sup> to room temperature with a velocity of 20 °C/min.

<sup>The performance</sup>  
<sup>was done with various</sup> Performance of the Braun tube surface treatment films prepared in the<sup>was</sup> embodiments <sup>was</sup> [were] evaluated. The  
 5 performance evaluation was performed on transmittance, reflectance, surface resistance, strength, light resistance, and the amount of bleeding. Hereinafter, each of the performance evaluating methods<sup>will be</sup> [is] briefly explained.

10 The surface resistance was measured by a simplified surface ohm-meter (made by Nihon Yuka Co.) using a <sup>4-pin</sup> [4-pins] probe or a <sup>2-pin</sup> [2-pins] probe. The reflectance and the transmittance were measured by a spectrophotometer (U3500 made by Hitachi Ltd.) using an integrating sphere for  
 15 eliminating <sup>any</sup> [an] influence by random reflection. The film quality (surface roughness) was measured by a gross-meter (made by Horiba Seisakusyo Ltd.), and it <sup>was</sup> [had been] confirmed that the film quality of any one of the films was at least<sup>a</sup> gross value 98, and the influence of the random reflection  
 20 was scarce. However, in some cases, the reflectance [could] <sup>was to be</sup> (be) deemed [as] high [performance] owing to some influence of the random reflection. Therefore, the reflectance was measured exactly using the integrating sphere measuring system.

25 The film strength was measured by a eraser test. The film was rubbed with an eraser (5030 made by Lion Co.) with a load of 1 kg, and the strength was determined as the number of rubbing<sup>operations</sup> until the gross change of the film became at

least 10 %.

The light resistance was determined by measuring a change in transmittance at 570 nm after irradiating the film with [an] ultraviolet<sup>ray</sup> (360 nm) of 4 mW/cm<sup>2</sup> for 300  
5 hours.

The amount of bleeding was evaluated as a change in transmittance after forming the laminated layers, taking the single layer of the film containing the coloring material as a standard. The transmittance at 570 nm after  
10 lamination becomes somewhat smaller than that of the single layer of the film containing the coloring material owing to the Ag-Pd film. Therefore, the measurement was performed on the single layer of the film containing the coloring material having the Ag-Pd film at its lower layer,  
15 and it was taken as the standard. The amount of bleeding  $\Delta T$  was calculated by the following equation.

$$\Delta T = \{(\text{transmittance at 570 nm after lamination}) - (\text{transmittance at 570 nm of the single layer of the film containing the coloring material})\} / (\text{transmittance at 570 nm of the single layer of the film containing the coloring material})$$

The results of<sup>the</sup> performance evaluation of respective surface treatment <sup>films</sup> [film] prepared as described above are indicated in Table 1.

Table 1

	Surface resistance ( $\Omega/\square$ )	Transmittance (%)			
		450 nm	570 nm	650 nm	Luminous trans- mittance
Emb-1 <sup>1)</sup>	350	75	59	85	85
Emb-2	350	67	47	72	72
Emb-3	350	67	47	72	72
Com-1 <sup>2)</sup>	4200	65	48	71	70
Com-2	8000000	82	78	89	86

Table 1(continued)

	Reflectance (%)		Eraser test	Light resist- ance $\Delta t$	Amount of bleeding $\Delta T$
	555 nm	luminous reflectance			
Emb-1 <sup>1)</sup>	0.36	0.85	150	5	20
Emb-2	0.32	0.68	200	5	1
Emb-3	0.35	0.78	200	2	1
Com-1 <sup>2)</sup>	2.3	3.8	50	50	0
Com-2	2.8	3.7	50	28	62

In the embodiments 1-3, the reflectance <sup>were</sup> less than 1 %, even if the transmittance <sup>were</sup> made small. <sup>was</sup> Their differentials were less than 2, and flat reflectance curves were obtained. On the other hand, in the comparative examples 1-2, the transmittance <sup>were</sup> made small, but the reflectance <sup>was</sup> larger than 2 %, <sup>could</sup> their differentials were larger than 3, and the reflectance curves were not flat. <sup>the</sup> And, anti-reflection characteristics <sup>can</sup> not be obtained. In accordance with these results, it is <sup>seen</sup> revealed that the reflectance curve becomes flat by arranging the coloring material layer under the metallic film, <sup>the</sup> such as Ag-Pd film, and the anti-reflection characteristics can be made preferable. <sup>also seen</sup> It is revealed from the results indicated in Table 1 that the light resistance can <sup>also</sup> be made preferable by arranging the coloring material layer under the metallic film. The metallic film has a high reflectance, and reflects incident light significantly at a boundary plane of the metallic film. Accordingly, transmittance of the incident light to the film at <sup>a</sup> lower layer than the metallic film is decreased, and <sup>the effect on</sup> effects to the reflectance and deterioration of the coloring material by irradiation of ultraviolet <sup>ray</sup> can be suppressed. The light resistance is increased further if ATO fine particles are mixed into the coloring material layer, as indicated by the embodiment 3. <sup>this is because</sup> Because the ATO fine particles absorb ultraviolet <sup>ray</sup>, and the light resistance can be improved by not only ATO, but also any material <sup>which</sup> is transparent and absorbs ultraviolet <sup>ray</sup>. For instance,

ZnO, ITO, TiO<sub>2</sub>, carbon, and the like are materials corresponding to the above material. Their effects could be confirmed by forming films <sup>by actual</sup> [with] mixing <sup>d</sup> [actually] these materials. However, as carbon is not transparent, its content must be suppressed as much as <sup>possible so to</sup> not [to effect <sup>of fact</sup> its] <sup>of the material</sup> transmittance.

In accordance with the embodiments 2 and 3, the film strength is increased more than that of the embodiment 1, and the amounts of bleeding are decreased. In a case <sup>in which an</sup> [when] organic resin is added, the film becomes dense even in a dried condition, and the amount of bleeding is decreased. When treated at 160 °C, the adhesion force of the film is increased, because the resin is <sup>a</sup> thermosetting resin, and, as <sup>a</sup> [the] <sup>the</sup> result, <sup>the</sup> strength of the film is increased. In accordance with the embodiment 1, the SiO<sub>2</sub> film and the Ag-Pd film are adhered <sup>to</sup> each other, but <sup>the</sup> metal and the SiO<sub>2</sub> film <sup>do not</sup> have <sup>a</sup> [not] desirable wettability <sup>to</sup> each other, <sup>so that</sup> [and readily] <sup>will readily occur</sup> [cause] contact failure. On the other hand, in accordance with the embodiment 2, wherein an organic resin is added, <sup>on</sup> [generating the] contact failure can be prevented, because a resin which is used for adhesion of metal and glass is added. A resin, such as <sup>an</sup> acrylic resin, epoxy resin, phenolic resin, and the like, could be used for the resin, and their advantages <sup>can</sup> [could] be confirmed by <sup>actual preparation of</sup> [preparing] the film <sup>actually</sup>.

In accordance with the embodiment 2, wherein ATO was added, <sup>d color</sup> [the] bleeding was prevented by adsorbing the coloring material with fine particles of the oxide.



Furthermore, <sup>with</sup> the addition of fine particles <sup>good</sup> is apt to (be) <sup>thought</sup> that the film strength is decreased, but actually, advantages as a filler are generated by optimizing the size and additive amount of the fine particles, and the film strength can be improved by <sup>reducing the</sup> [relaxing] internal stress of the film and preventing crack generation.

As explained above, (the) wavelength selective absorption characteristics can be added without lowering the reflection preventing characteristics by arranging the coloring material layer [at a layer] under the metallic film. And, it was revealed that the mechanical strength of the film could be improved by adding <sup>an</sup> organic resin and fine particles to the coloring material layer.

Furthermore, it was revealed that deterioration of the coloring material by ultraviolet <sup>ray</sup> [ray] could be prevented by arranging the coloring material [at a layer] under the metallic film, because the external light <sup>then reaches</sup> (reached) the coloring material after being weakened by the metallic film.

Conventionally, if a material having no light resistance, such as dyes was used with a high concentration, the material <sup>tended to become</sup> [was] deteriorated by irradiation of ultraviolet <sup>ray</sup> [ray] from fluorescent light. Therefore, it was difficult to use <sup>such</sup> (the) dyes, and <sup>the</sup> only <sup>remaining option</sup> [one means] was to use pigments. However, the pigments had an absorption peak broader than that of <sup>the</sup> dyes, and the wavelength selective absorption characteristics <sup>were</sup> [was] somewhat worse than that of the dyes.

In accordance with the result of the present embodiment, <sup>in which</sup> [such that] the light resistance could be improved, use of

the dyes was made possible instead of the pigments which had been used widely, and it was found that the wavelength selective absorption characteristics could be improved. Therefore, it was revealed that Braun tubes having<sup>an</sup> enhanced high contrast could be manufactured.

The above embodiments <sup>have referred to the use of</sup> are explained with<sup>a</sup> a film having a three layered structure, but ~~(the)~~ surface treatment film having a four-layered structure <sup>layers;</sup> ~~(and)~~ more can be used within the scope of ~~(feature of)~~ the present invention. In <sup>such</sup> the above case, another film can be arranged between the high reflectance layer and the absorption film. ~~(Some)~~ <sup>in some</sup> cases, another film can be arranged between the coloring material layer and the display plane.

As explained above, in ~~(accordance with)~~ a high definition display apparatus having an anti-static and anti-reflection film <sup>formed</sup> ~~(composed)~~ by laminating oxide or metallic thin films, at least three layers of oxide or metallic films having<sup>a</sup> different reflectance<sup>from</sup> each other are laminated on the surface of the display device, and the laminated film is <sup>formed</sup> ~~(composed)~~ so that an absorption film containing coloring material is arranged at a layer lower than the high reflectance film <sup>as seen</sup> ~~(in view)~~ from the surface of the display device. Owing to <sup>use of a</sup> ~~(the)~~ thin film of low resistance and high refractive index<sup>as</sup> explained above, the surface treatment film having a wavelength selective absorption effect and an anti-static and an anti-reflection effect, and a luminous reflectance equal to or less than 2 % can be formed, and a high definition display

apparatus having <sup>a</sup>high contrast and <sup>good</sup>safety, which can shield <sup>leakage</sup>  
(leak)electromagnetic waves, can be provided.

In accordance with the present invention, a high  
definition display apparatus having <sup>a</sup>high contrast and <sup>good</sup>  
5 safety, which can shield <sup>leakage</sup>(leak)electromagnetic waves, can  
be provided.